

REMARKS

Claims 28 – 40 are in the application for consideration.

Reconsideration of the application is requested in view of the amendments made in the claims and the remarks appearing below herein,

1. Applicants appreciate the courtesy of the examiner in correctly renumbering the claims in the application, which were inadvertently incorrectly numbered when the application was filed.
2. The specification has been amended with respect to formula (IV) which represents a preferred group of polyfunctional monomers for use in the present volume holographic recording medium. In order to be a polyfunctional monomer “p” must be an integer of at least three.

This amendment does not involve any objectionable new matter and is fully supported by the application as originally filed. For example, at page 6, lines 12 and 13, it is stated that a variety of tri-, tetra- and higher polyepoxysiloxanes have been found to be useful as the polyfunctional monomers.

The specification also has been amended with respect to the formula for the polyfunctional epoxide monomer used in Example 3 (shown on page 14). The formula has been corrected to show that each functional siloxane unit includes the oxygen atom. This amendment does not involve any objectionable new matter since the specific polyfunctional monomer is disclosed as a monomer of Formula IV which correctly shows that each functional unit includes the oxygen atom. Thus, it is obvious that each functional siloxane unit of the specific formula shown on page 14 should include the oxygen atom.

3. Claims 28 – 40 have been amended to recite specifically a volume holographic recording medium. In addition, the dependency of claims 29 – 40 has been amended in accordance with the renumbered claims (although the examiner may have already done so).

Claim 28, the only independent claim in the application has also been amended to even more particularly point out and distinctly claim applicants' advantageous volume holographic recording medium.

The claim now recites that the recording medium is capable of forming a volume hologram solely by cationic polymerization initiated by exposure to imagewise actinic radiation. The amendatory matter is fully supported by the disclosure of the application. See, for example, page 4, line 26 to page 5, line 8 and the examples.

The requirements of the binder material are also now recited. This amendatory matter is fully supported by the application as originally filed. See, for example, page 8, lines 13 – 16.

Claim 36 has been amended with respect to the definition of "p" and "q" in formula (IV) in the same manner as described above with respect to the amendment made in the specification.

4. The rejection of claim 30 (originally numbered 17) under 35 U.S.C. § 112 has been overcome by amending the claim as suggested by the examiner.

5. A number of rejections have been asserted against the claims as follows:

A. Claims 28 and 30 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Canadian Patent 995843 ("Watt").

B. Claim 28 has been rejected under 35 U.S.C. § 103(a) as being unpatentable over Watt. (Presumably, the examiner intended this rejection to apply to a different claim since the same rejection was made in A above).

C. Claims 28 –31, 39 and 40 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent 5,702,846 (“Sato et al”) in view of U.S. Patent 4,950,567 (“Keys et al”).

D. Claims 28 –31, 39 and 40 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over WO 97/13183 (“Dhal et al”) in view of U.S. Patent 5,698,345 (“Ohe et al”) and Keys et al.

E. Claims 28 –31, 39 and 40 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Dhal et al in view of Ohe et al, Keys et al and Sato et al.

F. Claims 28 – 40 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Dhal et al in view of Ohe et al, Keys et al and J. Polymer Sci (“Crivello et al”) and/or EP 0 391 162 (“Eckberg et al”).

The claimed subject matter of applicants is directed to a volume holographic recording medium which includes both a difunctional epoxide monomer or oligomer and a polyfunctional epoxide monomer or oligomer. Applicants have discovered that the claimed holographic recording media with a combination of difunctional epoxide monomers or oligomers and polyfunctional epoxide monomers or oligomers record volume holograms with very low shrinkage thus rendering these media particularly suitable for use in digital data storage applications.

Enclosed with this Amendment is the Affidavit Under 37 CFR § 1.132 of David A. Waldman, one of the applicants in the application. The affidavit presents data relating to the formation of volume holograms by cationic polymerization for a composition which includes only a difunctional epoxide monomer (the “prior art”) and for two compositions according to the present invention, one of which includes the same difunctional epoxide monomer and a tetrafunctional epoxide monomer and the other of which includes the same difunctional epoxide monomer and a trifunctional epoxide monomer.

The data show conclusively that for the volume holographic recording media according to the invention stable volume holographic formation is obtained with a relatively lower threshold exposure fluence whereas for the volume holographic recording medium which included only the difunctional epoxide monomer stable volume holographic formation is observed at a much later time period with a much higher threshold exposure fluence. These results are unexpected in view of the prior art teachings.

The data show that the unexpected differences in the results obtained for the volume holographic recording media according to the invention are due to the combination of the difunctional and polyfunctional epoxide compounds since the reactive groups in each compound are identical. The much higher threshold energy fluence required for the difunctional epoxide monomer to provide stable volume holographic formation indicates that although chemical reaction is taking place upon exposure, volume holographic image formation is not occurring as quickly as in the case of the media which contain both difunctional and polyfunctional epoxide compounds. The unexpected much faster stable volume holographic formation provided by the recording media of the invention is critical for digital holographic data storage applications.

A higher molecular weight structure can be achieved by the claimed recording medium for the same number of photo-initiation events because of cross-linking. According to the invention, stable molecular structures for stable volume holograms can be achieved with fewer photo-initiation events.

The affidavit also presents data relating to the volume change (shrinkage) of liquid monomers and the solid polymerized films of the monomers for a difunctional epoxide monomer, a trifunctional epoxide monomer and a tetrafunctional epoxide monomer, each of the monomers having the same chemical structure for the epoxy grouping. The data show significantly reduced volume shrinkage for the films made with the tri- and tetrafunctional epoxide monomers in comparison to the film made from the difunctional epoxide monomer.

The rejections will now be considered in the order listed above.

A. The examiner has referred to the contents of the composition of Example 18 of Watt and has concluded that it would be obvious to include therein poly(vinyl pyrrolidone) which is taught in Example 25 (page 38) as inhibiting premature gelation of polymerizable epoxide composition.

Applicants traverse this ground of rejection. The composition disclosed in Example 26 of Watt does include di- and multifunctional epoxide compounds (as well as a monofunctional epoxide compound) but does not include any binder material let alone an inert binder material as recited in the present claims. Even, assuming *arguendo*, that it would be obvious to include poly(vinyl pyrrolidone) in the composition of Example 26 the resulting composition would not be suitable to form a volume hologram.

In order to form a stable volume hologram the binder and the monomer(s) cannot form one chemical structure during polymerization. It is necessary that there be chemical segregation between the binder material and the resulting polymerized species formed in order to obtain a volume hologram. Applicants' claims, as amended, recite specifically that the binder does not inhibit cationic polymerization of the difunctional and polyfunctional monomers or oligomers and the refractive index of the binder is significantly different from that of the polymerized difunctional and polyfunctional monomers or oligomers.

Poly(vinyl pyrrolidone), if incorporated in the composition of Example 26 would inhibit cationic polymerization of the epoxide monomers and, further, the refractive index difference between the poly(vinyl pyrrolidone) and the polymerized structure obtained from the epoxy materials would not be suitable to form volume holograms of sufficient strength.

Reconsideration of this ground of rejection and withdrawal thereof are respectfully requested.

B. The examiner has referred to Example 3 of Watt as teaching a composition of an epoxide (bisphenol A) and epoxy cresol novolak (polyfunctional epoxide) mixed with stilbene cyclopentadienyl iron tosylate to render the composition light sensitive and has concluded that it would have been obvious to one skilled in the art to

add a binder to the composition of Example 3 to render the composition aqueous developable.

Applicants traverse this ground of rejection. As discussed above, in order to form stable volume holograms in accordance with applicants' volume holographic recording media it is necessary to have a binder with specific properties. There is no suggestion in Watt which would lead one skilled in the art to incorporate in the composition of Example 3 of Watt a binder which would not inhibit cationic polymerization and which has a refractive index significantly different from that of the polymerized difunctional and polyfunctional monomers or oligomers for the purpose of providing a composition for forming volume holograms by cationic polymerization.

Reconsideration of this ground of rejection and withdrawal thereof are respectfully requested.

C. In the rejection of claims 28 –31, 39 and 40 as being obvious over Sato et al in view of Keys et al the examiner has referred to: the Sato et al teaching of: useful cationic polymerizable compounds; the use of compounds having siloxane groups increases the refractive index modulation; the use of multiple epoxides is disclosed; Example 2 includes a cationically polymerizable siloxane compound, a free radically polymerizable compound, photoinitiators for each and a polymeric binder.

The examiner has also referred to Keys et al for the teaching that when more cross-linking is desired the use of multifunctional monomers in amounts up to 5% is a means to achieve this result.

The teaching of Sato et al to use various siloxane monomers in holographic recording media is in the overall context of increasing refractive index modulation which results in increased diffraction efficiency. Sato et al teaches that it is preferred to use a holographic recording medium that employs free radical polymerization of ethylenically unsaturated monomers for the hologram image formation. This reference also teaches cationic polymerization of siloxane monomers, which may be multifunctional, but in a post imaging flood illumination step that uses irradiation of UV light and/or visible light on the total surface of the imaging medium.

Sato et al does not teach the usefulness, as recited in the present claims, of a siloxane monomer in a volume holographic recording medium which employs only cationic polymerization to form volume holograms. Further, the reference does not teach or suggest the use of a specific combination of difunctional and polyfunctional monomers or oligomers as is required by the present claims.

Keys et al teaches a recording medium which has solid ethylenically unsaturated carbazole monomers which typically contain the ethylenically unsaturated group in the terminal position. Such monomers are polymerized solely by employing free radical polymerization to produce a cross-linked polymeric material. There is no mention of cationic polymerization as is required by the present claims.

This reference teaches the enhancement of the diffraction efficiency of reflection holograms by utilization of a post-exposure, i.e., subsequent to hologram formation, thermal treatment step. It is in the context of attaining improvement in refractive index modulation after image formation that Keys et al teaches the use of multifunctional monomers. Keys et al also teaches (column 13, lines 1 –10) that the thermal treatment can concurrently fix the enhanced hologram by thermally hardening or polymerizing the material in the hologram. This will, of course, be accompanied by additional volume shrinkage.

Thus, Keys et al does not teach or suggest anything with respect to the use of multifunctional monomers or oligomers being important to the formation of volume holograms during imaging and, further, does not teach anything regarding reduction of volume shrinkage which otherwise accompanies polymerization reactions.

Neither of these references teaches or suggests formation of volume holograms solely by cationic polymerization initiated by exposure to imagewise actinic radiation. These references, viewed individually or in combination, would not place the public in possession of applicants' presently claimed volume holographic recording media as is necessary to properly support a rejection under Section 103(a). Only the specific and detailed disclosure of applicants in the present application provides such teaching.

Reconsideration of this ground of rejection and withdrawal thereof are respectfully requested.

D. Claims 28 –31, 39 and 40 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over WO 97/13183 (“Dhal et al”) in view of U.S. Patent 5,698,345 (“Ohe et al”) and Keys et al.

Dhal et al has the same assignee as the present application and represents an earlier stage in the development of the imaging medium claimed in the present application. Dhal et al discloses a process in which a volume phase hologram is formed by cationic polymerization within a holographic medium. Among the cationically polymerizable monomers and oligomers disclosed by Dhal et al are the difunctional monomers disclosed in the present application. However, Dhal et al does not disclose the use of difunctional and polyfunctional monomers or oligomers in combination as is recited in the present claims.

The discussion in Dhal et al regarding the choice of monomer or oligomer is at page 6, line 21 to page 7, line 8. All the worked examples of Dhal et al use either the compound of Formula (I) in which R is a methyl group or a 1,2-epoxy-1,2,3,4-tetrahydronaphthalene as the polymerizable monomer.

The disclosure of Keys et al has been discussed above. One skilled in the art would find no suggestion in Keys et al which would provide an incentive to take from Keys et al, out of the context of the overall teaching of the reference in which the use of multifunctional monomers is described, to use multifunctional monomers in the method of Dhal et al in conjunction with difunctional monomers or oligomers..

Ohe et al teaches a photosensitive recording material which includes a solvent-soluble thermosetting epoxy oligomer capable of cationic polymerization. It is important to recognize that this reference teaches that when the medium is subjected to holographic exposure radical polymerization occurs and only a latent image is formed. Subsequent application of heat is required to actually produce a volume type phase hologram.

The reference teaches that the volume hologram can not be formed by overall exposure to UV or other actinic irradiation after the holographic exposure and before heat treatment and states that the reason for this is that the additional exposure to laser

interference light before heat treatment will result in generation of acid species that will be uniformly distributed thereby preventing the required formation of a permanently chemically segregated structure necessary for volume phase hologram formation. Additionally, Ohe et al teaches that cationic polymerization occurs specifically during the subsequent heat treatment step.

Accordingly, the fact that the medium of Ohe et al only forms a latent image during exposure to actinic radiation and then requires an immediate heating step to form a volume hologram renders the medium entirely unsuitable for multiplexed image recording which is required for holographic data storage. The reference does not teach anything with respect to a volume holographic recording medium that can form volume holograms solely by cationic polymerization initiated by exposure to actinic radiation.

In summary, Ohe et al and Keys et al do not provide the teaching which is lacking in Dhal et al so as to place the presently claimed imaging medium in the possession of the general public as is required to support a rejection under Section 103(a).

Reconsideration of this ground of rejection and withdrawal thereof are respectfully requested.

E. Claims 28 –31, 39 and 40 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Dhal et al in view of Ohe et al, Keys et al and Sato et al.

Applicants traverse this ground of rejection for the same reasons discussed above with respect to each of these references. It would not be obvious to take from each of Ohe et al, Keys et al and Sato et al only so much of their disclosures, out of the overall context of what the references teach, to support the rejection of the claims..

Reconsideration of this ground of rejection and withdrawal thereof are respectfully requested.

F. Claims 28 – 40 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Dhal et al in view of Ohe et al, Keys et al and J. Polymer Sci (“Crivello et al”) and/or EP 0 391 162 (“Eckberg et al”).

The examiner has alleged that it would be obvious to use other siloxane compounds known to be useful cationically polymerizable materials, such as those disclosed by Crivello et al and/or Eckberg et al in place of those specifically used in the examples of Dhal et al as modified by Ohe et al and Keys et al with a reasonable expectation of achieving comparable results. The examiner has also alleged that any cationically polymerizable compound(s) would be useful in the compositions of Dhal et al.

Applicants traverse this ground of rejection. Dhal et al, Ohe et al and Keys et al have been discussed above. Crivello et al has been cited to show the use of various epoxy silane compounds as shown in Tables I and II and Eckberg et al has been cited to show the use of cationically polymerizable compounds and the properties achieved through their use.

Crivello et al teaches various silicon-containing epoxy monomers and their properties but does not contemplate their use for a holographic recording medium let alone suggest that such use may be possible.

Eckberg et al teaches the use of hydroxyfunctional compounds with epoxyfunctional silicone compositions for coatings which have useful release properties. There is absolutely no relationship between the disclosure of Eckberg et al and the volume holographic recording medium of applicants.

The broad teaching of Dhal et al does teach each and every possible combination of cationically polymerizable materials within the broad teaching of that reference. The present claims require a combination of difunctional and polyfunctional epoxide monomers or oligomers. As discussed in detail above, applicants have found that the claimed combination of materials provides a volume holographic medium with reduced shrinkage rendering these media particularly suitable for use in digital data storage applications and also exhibit lower threshold energy for hologram formation thus allowing increased writing speed in data storage applications.

These references, viewed individually or in combination, do not properly support the rejection. As pointed out above, in order to properly support a rejection of

claimed subject matter under Section 103(a), a reference or references must place the public in possession of the claimed subject. Here, it would not be obvious to take from each of the secondary references only so much of their disclosures, out of the overall context of what the references teach, to support the rejection of the claims.

Reconsideration of these grounds of rejection and withdrawal thereof are respectfully requested.

In summary, the claims have been amended to even more particularly point out and distinctly claim applicants' advantageous volume holographic recording medium. The claims have been shown to be proper in form for allowance and in substance to be patentably distinguishable over the references of record. Reconsideration of the application and allowance of the claims are respectfully solicited.

Respectfully submitted,



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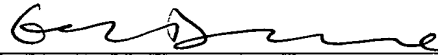
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Enclosures

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